THE FEASIBILITY OF COMPUTERIZED PRECISION ASSESSMENT OF ELEMENTARY MATHEMATICS SKILLS

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL
OF THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1979

To John, my husband and best friend,
and to the expression of our love,
John Christopher, III.

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my committee members for their support, encouragement, and for their constructive suggestions, with special thanks to Dr. Bill Hedges for his encouragement, guidance, and intellectual stimulation throughout my program. Deserving of special acknowledgment is my chairman, Dr. Bill Drummond, for consulting and training skills, advice, and support.

I would also like to extend my appreciation to Dr. Bill Wolking for his cooperation throughout the summer program, and to Steve Summers for his technical assistance with the computer programming.

Finally, I wish to acknowledge my husband, John, who has given me the emotional and intellectual support I've needed throughout my program.

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December, 1979

Chairman: William H. Drummond
Major Department: Curriculum and Instruction

This study examined the feasibility of utilizing the PLATO computer system to assess learner's basic skills in addition, subtraction, multiplication, and division. Nine exceptional learners ages 8 and 9 were given computer assessments and teacher assessments simultaneously. Learners were evaluated for speed as well as traditional accuracy of performance. The computer assessment averaged 5.7 times faster than teacher assessment for the same skills. Computer and teacher assessments agreed on 91% of the skills tested. The computer was more accurate in assessment of the disputed skills. A relationship was not established between typing speed on the computer keyboard and the speed of writing digits.

CHAPTER I

Statement of the Problem

There were two purposes for this study: (1) to determine the feasibility of combining precision assessment with computer technology in order to assess the mathematics skills of elementary students, and (2) to compare computerized precision assessment of mathematics skills with teacher administered precision assessment of the same skills. Learners were assessed by both an interactive computer program, and by a teacher administered precision assessment; the efficiency and feasibility of these two methods were then compared. The criteria for feasibility used was the speed and accuracy of the assessment. Specifically, the study addressed the following questions:

1. How does testing time for computer assessments compare with time for teacher assessments?

2. How does accuracy of the results of the computer assessments compare with the results of the teacher assessments?

3. How does the speed of typing answers on the computer assessment compare with the writing of answers on the teacher assessment?

Rationale

Studies have shown the advantages of computer diagnosis over teacher diagnosis of learning problems (Ferguson, 1971; Hsu & Carlson, 1973; Jones & Sorlie, 1976). These studies have demonstrated savings in time and increased accuracy of assessment when computers are properly programmed to assess discrete academic skills. However, all of the comparative studies to date have used traditional percentage correct criteria for evaluating the learner's performance.

Recent research has demonstrated advantages for using rate data for measuring learning performance and determining mastery of academic skills (Johnston & Pennypacker, in press). With this strategy, mastery is defined as fast and accurate performance, as opposed to traditional measurement of accuracy alone.

This study differs from previous studies by examining the comparative performance of computer diagnosis and teacher diagnosis using rate data as well as accuracy. The purpose of this research is to extend and build upon previous comparative studies (Ferguson, 1971; Hsu & Carlson, 1973; Jones & Sorlie, 1976) by examining the feasibility of computer diagnosis using rate measures of mathematics performance.

Testing involves five steps: (1) developing effective test items, (2) producing exams, (3) administering exams, (4) scoring responses to the items on exams, and (5) analyzing

and evaluating the test items and the exam effectiveness. The computer can provide the last four of these test functions (Zelnio, Ganon, & Pashion, 1977). Educators spend much of their time doing clerical work associated with evaluation. This time could be spent in planning activities or in actual interactions with learners (Doerr, 1975).

At every level of education, evaluation of learner achievement is required and records of that achievement have to be maintained. Individualizing instruction requires a greater frequency of evaluation and record keeping than many other types of programs (Doerr, 1975). Teachers who individualize instruction should grade each evaluative step before determining skill mastery, or the students will proceed through many steps above or below their mastery level (White & Haring, 1976).

Computers seem ideally suited to handle or manipulate testing functions. For example, computers can be programmed to provide equivalent test items for an objective; this is useful when students need to take the same test a number of times. Randomly generated items may also be used as exercises to achieve an objective. Computer testing can allow for differential treatment of students, allowing for differences in abilities, interests, rates, and goals (Ferguson, 1971). This is usually accomplished by using a branched program which can take the learner through different instructional sequences depending upon the past and present performance of the learner. This type of

program can minimize testing inappropriate levels of mastery. Computers can also be utilized for storage and retrieval of information describing student progress toward skill mastery.

According to Bitzer and Shaperdas (1970), it is "economicaly and technically feasible to develop large scale computer-controlled teaching systems for handling 4000 teaching stations that are comparable with the cost of teaching in elementary schools." Test data serve as the primary source of enabling individualization of programs. Studies have shown the advantages of computer diagnosis over teacher diagnosis (Ferguson, 1971; Hsu & Carlson, 1973; Jones & Sorlie, 1976). These advantages include

1. unlimited number of equivalent test items for the objectives for repeated testing or practice exercises,
2. differential treatment of students,
3. time savings over traditional testing,
4. freeing up teacher time for instructional activities,
5. avoidance of learner frustration due to inappropriate levels of test items,
6. provision for immediate storage and retrieval of data,
7. easy manipulation of criterion levels for mastery and non-mastery,
8. assurance of content validity by item generation,

9. higher scores than the traditional control group on comprehensive exams.

Items one through eight were reexamined in this study.

The computer diagnoses in previous studies have not taken rate data into consideration, but have used percentage criteria exclusively. This study differed from prior studies in its exploration of the use of rate data for diagnosis.

Precision assessment has been found to be more sensitive to individualized diagnosis of learning problems than evaluation using percentage criteria (Pennypacker, 1972). Under percentage criteria, the student "masters" a skill when he correctly answers a preset percentage of the items on a test. One recommended percentage is 90% correct (Block, 1974).

The key difference between precision assessment and traditional assessment is the emphasis on rate of performance as opposed to traditional percentage measures, and direct, continuous measurements of skill mastery. Accorddin to Lindsley (1971), precision teaching stresses the monitoring of improvements of desired behaviors in terms of frequency or rate measurement. Under a rate criterion, the dimension of time is added to the student's performance. The student is expected to achieve a high percentage of correct responses within a specified time. For example, a criterion frequently used in math instruction is 50 digits per minute with two or less errors (Lovitt, 1977).

The rationale behind high rates of accurate responding is that they insure against practicing errors and rapid loss of skills due to inadequate mastery. There is also some evidence that high rates facilitate performance on more complex skills (Haughton, 1971; Starlin, 1971).

In precision assessment, initial performance is used as a baseline for evaluating improvement. Daily monitoring is accomplished by means of a daily behavioral chart. This daily measurement is used as a basis for decisions regarding each student's individual curriculum (White & Haring, 1976).

Skinner (1938, 1961, 1968), Ulrich, Stachnick, and Mabry (1970) and others have pointed out advantages of utilizing rate data over the traditional use of percentages. Rate data increases the degree and sensitivity of information about the learning process. Percentage data, however, can be misleading without examination of rate data. For example, the skill of adding numbers at 10 digits per minute with 95% accuracy is quite different from the skill of adding 50 digits per minute with 95% accuracy. When only given accuracy data, the two skills above would probably be equated.

Precision assessment utilizes both rate and accuracy data for diagnosing deficiencies. This study examined the feasibility of utilizing a computer for precision assessment of elementary math skills. Feasibility was evaluated by comparing a computer administered precision assessment

with a teacher administered precision assessment of the same skills. The comparison was analyzed in terms of speed and accuracy of assessment.

Delimitations

The teachers selected for this study had demonstrated knowledge of precision assessment techniques. This may limit generalizations of the results to those teachers familiar with precision assessment techniques.

The program which controlled the computer assessment was written in the Tutor computer language which is specific to the PLATO system. This will limit usage of this computer program to those facilities possessing PLATO services.

There may have been a learning effect across testing conditions since the design called for two assessments on each subject. To control for this, the assessments were run simultaneously, so that the conditions would not be favorably biased in the direction of the teacher or the computer.

The sample used in this study was limited to 8 and 9 year old exceptional student education students in the Gainesville, Florida, area. This limits generalization to similar populations.

Definitions

There are key terms used in this study which will be clarified to their use in this study:

Feasibility - In order for an assessment to be practical for classroom usage, it must be reasonably accurate and it must be capable of administration within a reasonable period of time. Although these two factors are only a subset of the total feasibility issue, they are necessary factors. For the purposes of this study, feasibility was limited to speed and accuracy of the assessment.

Several terms are particular to precision technology. These terms are defined as they are used by White and Haring (1977):

Precision Assessment - Precision assessment is a procedure which uses rate measurement of learner performance to identify and remediate deficient skills. It is the initial step, or baseline, for precision teaching.

Precision Teaching - Precision teaching is the application of the principles of operant behavior to educational problems.

Probe - A probe is an instrument, device, or a period of time used to sample the learner's behavior.

Mixed Probe - A mixed probe contains items from a number of different, but related skills.

Single Probe - A single probe is a probe with items representing a single, specific skill.

Tool Skill Probe - a tool skill is considered a prerequisite skill to more complex skills. For this study, tool skill probes include writing digits and typing digits in a timed format.

Some of the terms used in this study have specific meanings in computer technology (McCarthy, 1971).

Hardware - Hardware is the physical parts of a computer including input and output devices, arithmetic circuits, control circuits, and memory circuits.

Software - Software is the program of instructions that puts a computer to work on a specific problem or task.

Interface - Interface is the problems, considerations, theories, and practices involved in matching the computer to the learner.

Overview

The remainder of this study is organized into four chapters and appendices. Chapter II presents the literature on programming strategies, a discussion of the precision assessment findings, and a review of preferred student-computer interfacing techniques.

Chapter III contains the questions relevant to this investigation, a description of programming features

used for the computer assessment, the procedures, design, and data analysis methods.

Chapter IV provides a discussion of the significant findings and results of the data analysis.

Chapter V contains a summary of findings, conclusions, and recommendations for further study.

The appendices contain instructions for the PLATO assessment, a comparison of the computer and teacher assessments, the data collected in the study, and information concerning the Sequential Precision Assessment Resource Kit (SPARK).

CHAPTER II

REVIEW OF LITERATURE

The literature search was assisted by a Council or Exceptional Children/ERIC Clearinghouse computer search. Since the primary objective of this study was to examine the feasibility of computerized assessment, the keywords "computerized assessment," "computer assessment," "computerized diagnosis," and "computer diagnosis" were used. Since the study was limited to elementary math skills, keywords of "math" and "mathematics" were used. In addition, the Cumulative Index of Journals in Education and the Cumulated Index Medicus were searched from 1970 to date using "computer diagnosis" as keywords.

The literature review will be divided into the following areas:

1. Programming strategies for computer assessment
2. Precision assessment
3. Interfacing computer with student

Programming Strategies for Computer Assessment

Lippey (1974) discusses five ways in which the computer can support test preparation: item banking, item generation, item attribute banking, item selection, and item printing. In addition to these test preparation

functions, the computer can administer tests, score responses, and prescribe instructional strategies based on the testing results. Two of these computer functions, item banking and item generation, are relevant to this study and will be discussed subsequently.

Item Banking

Item banking (Lippey, 1974) refers to the storage of questions in machine readable form by means of punched cards, magnetic storage, or by using a disc system. Cards are more frequently used for individual instructor's use, whereas centralized banking systems typically utilize magnetic or disc storage. Item banking allows item analysis, insuring more highly refined, reliable, and valid items.

There are many item banking systems cited in the literature (Ansfield, 1973; Baker, 1973; Remandini, 1973). In some item banking systems the instructor is the primary user of the system (Baker, 1973). Such systems are usually oriented toward the teaching of a particular course, but may include files for statistical analysis, banking of items, and test files which record each particular test generated. Some systems print the actual test which is then photocopied, thermofaxed, and duplicated for student use (Remandini, 1973). Other systems print the actual tests the student will take. More sophisticated systems output on ditto masters (Kayser & Klein, 1976).

In item banking, the actual test is usually a small subset from a large number of items which are banked. Test items may be drawn at random, or drawn by difficulty level, or category, or some other selection strategy. Items may be added or deleted from the item bank based on instructor's judgment or results of the item analysis measures. The choice of item banking or item generation strategies is largely determined by the content of the items. Some types of content lend themselves better to item banking, while others are programmed more efficiently by item generation.

Item Generation

In item generation, particular items are not banked or stored, but are generated by an algorithm or rule. Ordinarily, parts of these items are produced by a random number selection routine within the algorithm. Consequently, although the type of item to be generated is known, the particular item is not known ahead of time. Quantitative content items are particularly suitable to item generation. Vickers (1972) suggests that application of such a system is not limited to quantities which are purely numerical, but can be applied to subject material which "obeys a set of laws involving quantifyable parameters." A great deal of storage space is not required for such a system, as storage is primarily devoted to the program. The number of possible questions generated by such a system are

essentially infinite. Other examples of computer testing systems employing item generation include the programs described by Zelnio, Ganon, and Pashion (1977), Ferguson (1971), Hsu and Carlson (1973), and Suppes, Jerman, and Brian (1968).

Both Ferguson (1971) and Hsu and Carlson (1973) devised computer generated items to diagnose mathematics levels within the Individually Prescribed Instruction (IPI) system. After the items are generated, a branched program is utilized to diagnose the student's math skills. In these programs the content validity of the test is not a difficult issue to resolve since the objectives are defined in precise behavioral terms. Moreover, the procedure used to construct the test items assures the existence of high content validity (Ferguson, 1971).

Branched Testing

Branched testing is a strategy for routing the student to items which are neither too easy nor too difficult. Numerous studies have reported success with branched tests (Bayroff & Seeley, 1967; Waters, 1964; Hansen & Schwartz, 1968). Ferguson (1971) describes an item sampling and branching strategy which was found to reduce testing time. Others have questioned the use of such measurement devices since in many cases short conventional tests could achieve the same results with less complex test procedures (Cleary, Linn, & Rock, 1968; Angloff & Huddleston, 1958).

Lord (1970) believes that tailored tests are preferable when the test objective is to place students on

a hypothetical ability dimension. He describes a process of stepping up and down the difficulty scale to seek the student's level. In this way, each student is equally challenged. This is impossible in conventional testing where everyone takes the same items. Branching is the computer technique for this tailored testing concept. Branching enables the learner's available past history to influence the future course of item presentation.

Precision Assessment

Precision assessment is a system for pinpointing deficient skills in a learner's repertòire based on direct observation of the speed and accuracy of skill performance. Rate and accuracy criteria form the basis for instructional decision making. Many educators advocate the use of rate measures for assessment (Lindsley, 1971: Starlin, 1971; White & Haring, 1976).

Précision teaching is the application of the principles of operant behavior to educational problems. Although many of the techniques used today had their beginnings in the eighteenth and nineteenth centuries, their impact on special education was not widely felt until the late 1960's (Forness & MacMillan, 1970). Systematic techniques replaced the prior haphazard approaches of child management and motivation of exceptional children. These techniques enabled tailoring environments for individuals, rather than

perpetuating the learning problems due to the educator's inability to design a suitable environment (Forness & MacMillan, 1970).

Precision assessment and subsequent precision teaching assumes a five stage learning hierarchy consisting of the acquisition, fluency building, maintenance, generalization, and application phases. The acquisition phase consists of the time from which the learner first performs a behavior until he can perform the behavior with reasonable accuracy. The fluency building (or proficiency) phase begins with accurate performance of the behavior and continues until performance meets desired accuracy and rate criteria. When a learner can perform the behavior accurately and fluently after some interval without practice, he is in the maintenance phase. Performing the behavior fluently in situations which differ from the practice situation makes up the generalization phase. The learner has reached the application, or adaptation, phase when he can change the behavior to fit a new situation upon ascertaining the need to perform the behavior. These phases are not necessarily discrete entities, and can only be observed through continuous recording of the behavior (Haring, Lovitt, Eaton, & Hansen, 1978).

The development of the initial assessment involves defining and sequencing each skill of the curriculum. The skills should be stated in terms of behaviors and proficiencies the learner should demonstrate.

Mixed probes which assess several related skills are used to save assessment time and effort. The mixed probes quickly pinpoint where the learner's needs might be. Mixed probes are followed by single probes which are more uniform probes concentrating on those skills where the learner's needs seem to be the greatest. Repeated assessments over several days avoid inaccurate information due to one "off" day (White & Haring, 1976).

In almost every assessment there are some basic skills critical to the learner's success. In order to properly interpret the meaning of the assessments, the fluency of these tool skills must be assessed. The most common tool skills for academic learning are saying (letters, sounds, words, numbers), writing (letters or digits), and doing (marking check marks, moving cards or blocks, etc.). Tool skill performance should be assessed to insure that it is possible for the learner to achieve the criteria used for goal setting (White & Haring, 1976).

Data from precision assessment are used to place learners within an academic subject area, to establish long and short term objectives, to write systematic, specific instructional plans for each learner, to determine when to advance to new learning objectives, and to provide alternative instructional procedures.

Some researchers suggest that there are critical performance rates below which learners experience great difficulty in later learning. Haughton (1971) has

emphasized the importance of rate criteria based on observations from single subject designs in reading. Haughton reports that learners reading between five to thirty words correct per minute experience severe difficulties in blending and phonetic skills. He advocates the use of carefully selected speed and accuracy criteria to insure sequential mastery in reading, writing, and math. In a descriptive study, Starlin (1971) presents data which indicate that when oral reading rates are less than fifty words per minute, emphasis on learning opportunities for correction of errors produces little gain in reading performance. In addition, Starlin found that first graders who say letter sounds correctly at a minimum of forty words per minute progress more rapidly in reading than those who do not attain that rate. Bersoff (1973) sees traditional assessment based solely on accuracy criteria as the major stumbling block to changing math behavior.

There have been a number of successful attempts to individualize testing through item generation, branching, and through precision assessment methodology. This study will examine the feasibility of utilizing both rate and accuracy criteria, combining the technology of precision assessment with computer technology.

Interfacing Computer and Student

In order for a computer assessment to be utilized as a precision assessment, there needs to be a relationship

shown between typing answers and writing answers. In a review of the literature, Seibel (1972) reports typing entries on a typewriter-like keyboard to be only slightly slower than handprinting digits for non-typist subjects. Differences were found between daily production rates and speed test rates of card punching. When speed tests of less than one-half hour were compared with an average working day, there was almost a 2:1 difference in data entry. Rates are increased when operators are primed for taking a "speed test." Similar research was reported for typists (Seibel, 1972).

Review of the research also reveals that by means of instructions, punishments, and differential payoffs, operators can be induced to exchange speed for accuracy. Excessive stress on either speed or accuracy results in deterioration of performance in terms of rate of information transmission (Seibel, 1972).

In addition to typing digits, there are a number of other factors which influence the interaction between the student and the computer. Some of these factors will be discussed further.

McLaughlin (1978) discusses some of the subtle areas that deal with student-computer interactions, or interface. The purpose of interfacing is to make interaction with the computer as smooth as possible for the student. The areas to be discussed include editing of input, answer positioning, and timing routines.

Editing of input is designed to detect any non-numeric or otherwise inappropriate input. The student can also be provided with an "out" if the problem is beyond his or her ability by accepting a carriage return as a statement that the student has given up.

In answer positioning, the student is given the option of answering the questions from left to right, or from right to left. If the student wishes to solve the problem using mental computation, it may be easier to enter the entire answer from left to right. In some instances like long division problems, the student should have the capacity to work out the entire problem on the display. Elements of the computation may be on different lines and in different positions on these lines.

Timing routines involve the presentation of some type of prompt as the student takes an excessive amount of time to respond. If feedback is used, it should be given at the end of timed drills so that it doesn't interfere with the timing. For untimed drills feedback should be given immediately.

Some of the more general interfacing techniques which can increase interaction include: (1) alignment of numbers to avoid confusion, (2) use of the student's name in communications between the student and the computer, (3) a variety of negative and positive responses, randomly selected to avoid boredom, (4) informational messages for explanations

and to break up long sessions, and (5) variety of problem presentation formats to avoid boredom (McLaughlin, 1978).

A number of these interfacing techniques were included in the computer program for this study. These techniques are discussed in more detail in the methods section, Chapter III.

CHAPTER III

DESIGN

This chapter presents the methods and procedures of this study. Included is a description of subjects, equipment, setting, experimental procedures, and design.

The procedure used was composed of three stages:

1. The identification of subjects.
2. Computer and teacher assessments.
3. The evaluation of assessment findings.

A flow chart is presented in Figure 1 to aid conceptualization of the methods and procedures.

Subjects

The nine subjects for this study were selected from the students enrolled in the summer exceptional student education program at P. K. Yonge, the University of Florida's laboratory school. The students for this study were selected form the eight and nine year olds enrolled in the summer program. The computer assessment consisted of skills which were included in the Mathematics Curriculum for Alachua County. Although it was not known whether the students had mastered these skills, it was assumed that some of these skills had been introduced.

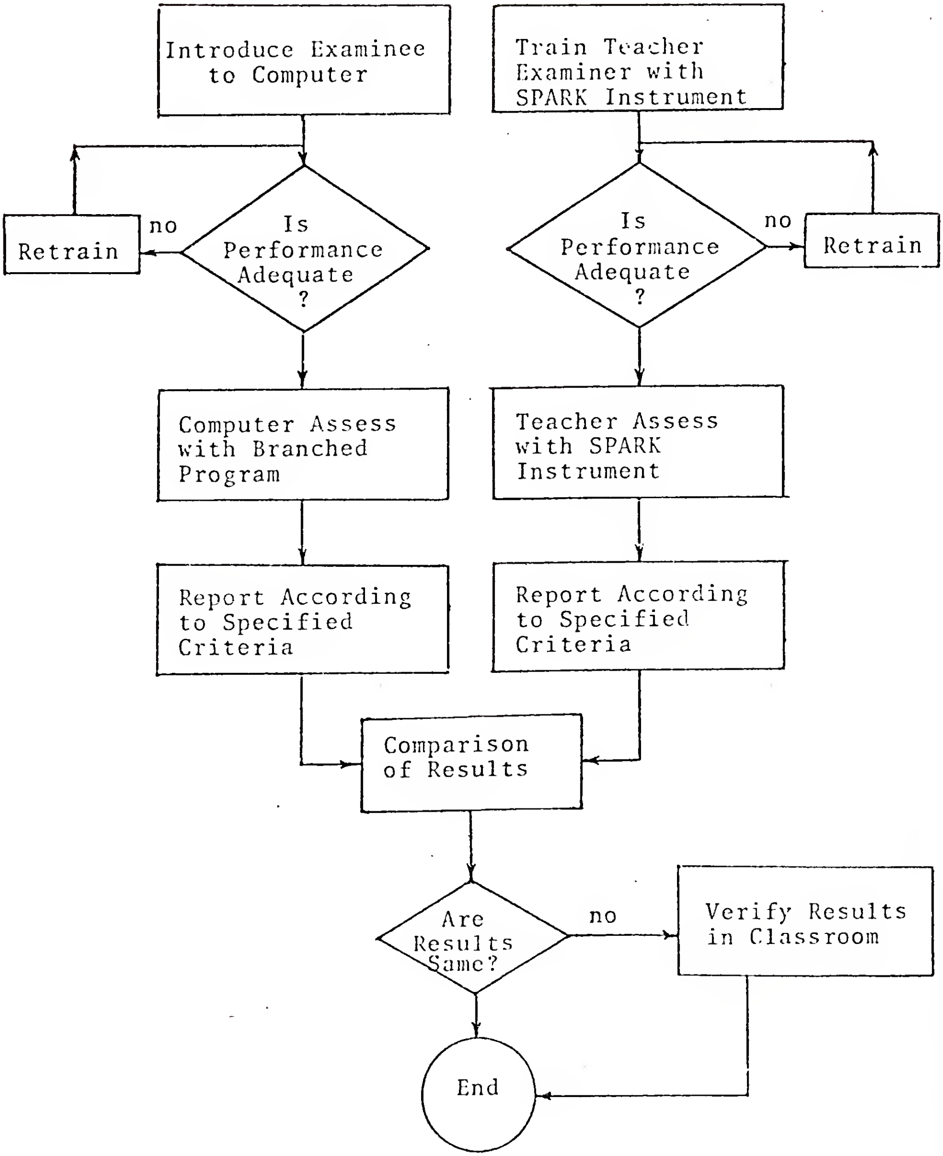

Figure 1

Flowchart of Procedures

Mixed probes were available for quickly identifying deficit skills, and single probes were available for confirmation of deficit skills and for assessing more specific performance information.

Parts of the math section of the SPARK were duplicated and used for the teacher assessment. The performance data obtained were used to determine mastery and instructional levels. More detailed information concerning the SPARK can be found in Appendix C.

Setting

The general setting consisted of 4 x 6 meter room in the PLATO laboratory at the J. Hillis Miller Health Center. The room was well lit and temperature regulated. The immediate setting included the student and experimenter seated at the PLATO system connected to a Cyber 73 unit.

Experimental Procedures

The experiment was divided into five consecutive procedural steps:

1. the identification of students and teachers
2. the conducting of a pilot study
3. the training of students and teachers
4. the administration of computerized and teacher assessments
5. the determination of assessment accuracy

Equipment

Computer Hardware

The computer assessment unit used was the PLATO IV terminal, consisting of a keyboard and plasma display unit. It was developed by the Control Data Corporation. The central processing unit was located in Tallahassee, Florida, and connected via telephone to the University of Flroida's PLATO facilities located in the J. Hillis Miller Health Center on the University of Florida Campus in Gainesville.

Computer Software

The computer program consisted of a branched program written in Tutor language. The assessment areas included sections from the addition, subtraction, multiplication, and division strands of the SPARK, Sequential Precision Assessment Resource Kit (Trifiletti, Rainey, & Trifiletti, 1977). Test items were generated using skill algorithms with restricted difficulty ranges. Scoring was accomplished internally and results were accessable to the experimenter. Assessment information included proficiency rates in terms of correct per minute, errors per minute, and actual errors. The program is currently on the Florida State University PLATO computing system, in Tallahassee, Florida.

Teacher Assessment Instrument

The Sequential Precision Assessment Resource Kit was a performance-based, precision assessment instrument. It included a listing of sequenced skill steps for content

areas of addition, subtraction, multiplication, and division. Reliability information on the SPARK is presented in Appendix C.

Computer Assessment

The computer presented mathematics problems to the student using a branched program, adjusting to the level of the individual student based on his/her responses to prior questions. The computer assessment was based on the SPARK instrument and programmed by the experimenter. (See Appendix B for further clarification of the computer and teacher assessments.) The computer collected data on both the speed and accuracy of the examinee's performance, as well as the total time of the assessment.

Teacher Assessment

Concurrently with the computer assessment, the teacher examiner administered the mixed probes of the SPARK, along with tool skill probes. Based on the speed and accuracy of the examinee's performance on these probes, the examiner determined which single probes to administer. Using predetermined cut-offs of 50% accuracy, the examiner provided detailed information of the subject's deficient skills. The examiner scored each probe and kept an accurate record of actual testing time, scoring time, and preparation time. Each examiner maintained a log of the time spent administering and scoring the assessment. Administration time included time spent gathering materials, giving instructions and timing probes.

Determination of Assessment Accuracy

The results from the computer and teacher assessment were compared. Each assessment finding which was not agreed upon by both the computer and the examiner was listed, and further examined for verification purposes. The experimenter gathered daily data on these skills to determine the accuracy of the assessments. Lindsley's (1971) precision teaching method was employed to gain a stable baseline of learner performance with respect to the skills in dispute.

Collection of data. The experimenter administered a daily, one-minute timed assessment for each of the probes in disagreement. The classroom teacher was instructed to avoid giving specific instruction or practice on skills in dispute during the four days of data collection.

Criteria for disagreement of assessments. The teachers were instructed and the computer programmed to further test skills on the mixed probes testing at greater than 50% accuracy. Any probes classified differently by the computer and teacher would affect the future direction of the assessment and therefore be considered a "disagreement of assessment."

The determination of criteria for disagreement was a difficult decision to make. There were no clearcut guidelines to use in creating a classification system. The experimenter, therefore, arbitrarily decided to use the schema found in school systems for assigning grades. There was no known research base for this category system. The category system was designed to select gross disagreements between the computer assessment and the teacher assessment.

Single probes were considered in disagreement when accuracy scores were categorized at least two categories apart. Categories were assigned by converting accuracy scores to percents and then classified as follows:

Accuracy Score	90-100%	=	Category A
Accuracy Score	80- 89%	=	Category B
Accuracy Score	70- 79%	=	Category C
Accuracy Score	60- 69%	=	Category D
Accuracy Score	$<$ 60%	=	Category F

For example, if the probe of multiplying fours was assigned to category A based on the teacher assessment and assigned to category C based on the computer assessment, the probe would be considered in dispute since C is two categories away from A. Follow-up data would then be collected on this probe for verification purposes.

Design

This study utilized a single subject multi-elemental design without baseline. Nine subjects received two treatments (assessments), and subsequent analysis was performed to determine the accuracy and efficiency of the assessments.

In traditional single subject research, treatment effects are evaluated against a baseline of behavior.

The baseline measurements usually preceed the treatment. It was felt in the present study, however, that the repeated measures required by the baseline would produce a learning effect which would alter the validity of the assessments (Campbell & Stanley, 1963). In addition, a prior baseline would have had to measure all of the skills assessed in order to contain information on disagreements between computer and teacher finding. This would be too lengthy and frustrating for the student (White & Haring, 1976).

For these reasons, the baseline phase followed the treatment phase and included skills on which the assessment disagreed. This greatly reduced the number of skills needing examination.

Data Analysis

The data were analyzed in terms of efficiency (time for assessment), and accuracy. A simple graphic comparison was made between the computer's assessment time and the teacher's assessment time. Data analysis also included an analysis of the accuracy of assessment. Verification collected by the daily timed assessments was used to confirm discrepancies and to assign error to computer assessment or teacher assessment.

Correlations for the comparison of typing digits with writing digits were derived using the Statistical

Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975) and the computer facilities of the Northeast Regional Data Center in Gainesville, Florida.

Summary

The data for this study consisted of responses of nine students to mixed and single probes assessed by a computer and by a teacher. Those pinpoints in disagreement were further examined by administering one minute daily timings for a period of four days.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to determine the feasibility of combining precision assessment with computer technology for assessing elementary mathematics skills. This was accomplished by comparing a computer administered precision assessment with a teacher administered precision assessment of the same skills.

Comparison of Assessment Time

One of the means for comparing the computer administered assessment was the amount of time for the assessment. Table 1 presents the assessment time for the computer and teacher assessments. The teacher assessment time included time spent gathering and organizing materials, giving instructions, and timing the probes. The computer assessment time was based upon the computer's record of on-line time for each student. This time began as soon as the student was signed on by the experimenter, ended when the experimenter signed off, and included false starts. Because there was no machine down time during the computer assessment period, none was included in the computer

Table 1

Comparison of Computer Time for Assessment
And Teacher Time for Assessment

Learner	Computer Assessment Time	Teacher Assessment Time
1	52 mins.	6 hrs. 50 mins.
2	47 mins.	7 hrs. 20 mins.
3	51 mins.	3 hrs. 55 mins.
4	57 mins.	4 hrs. 5 mins.
5	20 mins.	3 hrs. 50 mins.
6	40 mins.	3 hrs. 10 mins.
7	33 mins.	2 hrs. 30 mins.
8	36 mins.	2 hrs. 0 mins.
9	35 mins.	1 hr. 40 mins.
	Mean = 41 mins.	Mean = 3 hrs. 56 mins.

assessment time. Computer assessments were administered in one sitting on one day. Teacher assessments were spread over two to four days due to the time needed to score and record the results between assessments. The teachers were also assessing other areas not included in this study.

In all cases the teacher assessment time exceeded the computer assessment time. Data revealed that the average computer assessment was about 5.7 times faster than the average teacher assessment for the same skills. Two apparent reasons for the discrepancy in assessment time were (1) the capacity of the computer to score and record learner responses almost instantaneously and (2) the capability of the computer to assess learners without gathering, duplicating and organizing materials for each assessment.

Comparison of Assessment Accuracy

Appendix D shows the raw scores and percentages for the mixed probes and single probes and the raw scores for the tool skill probes. Those probes in disagreement are included in Table 2 and Table 3.

The computer program was written to give a minimum of four problems for each skill. Problems were presented until this minimum was attained. Therefore, in all cases the computer administered more problems on the mixed probe than was administered in the teacher assessment. Based on

Table 2

Discrepancies in Mixed Probe Results
Between Computer and Teacher Assessments

		Computer Assessment		Teacher Assessment	
Learner	Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
2	X1	4/8	50%	3/3	100%
2	X2	6/6	100%	1/5	20%
2	-0	8/8	100%	0/3	0%
3	+1	4/5	80%	1/3	33%
3	+2	6/7	86%	1/3	33%
3	÷3	6/10	60%	1/3	33%
4	X1	6/6	100%	0/3	0%
4	X3	11/11	100%	0/3	0%
4	X4	6/13	46%	10/10	100%
4	-0	6/7	86%	1/3	33%
5	-9	0/6	0%	4/6	67%
6	X3	8/12	75%	1/2	50%
6	X4	2/9	22%	4/5	80%
7	+4	2/6	33%	3/3	100%
7	+7	5/11	45%	4/4	100%
7	-0	2/5	40%	3/5	60%
7	-3	8/8	100%	2/5	40%
7	-5	6/7	86%	1/5	20%
9	+1	7/8	88%	0/3	0%
9	+2	10/11	91%	1/3	33%
9	+3	11/12	92%	2/4	50%
9	+4	4/4	100%	2/4	50%
9	-1	4/6	67%	1/3	33%

Table 3

Discrepancies in Single Probe Results
Between Computer and Teacher Assessments

		Computer Assessment		Teacher Assessment	
Learner	Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
1	X4	9/13	69%	30/30	100%
1	X5	14/22	64%	23/23	100%
3	÷2	11/15	73%	14/14	100%
3	+3	19/25	76%	13/13	100%
3	-3	10/13	77%	*	*
4	-0	6/7	86%	1/3	33%
6	X2	2/3	67%	18/18	100%
6	X3	2/12	17%	36/36	100%
7	+1	6/21	29%	64/64	100%
7	+2	23/25	92%	32/44	73%
7	+3	17/22	77%	27/29	93%
7	-3	18/23	78%	15/16	94%
7	-5	22/30	73%	22/22	100%
8	*	*	*	*	*
9	+1	15/16	94%	4/34	12%

* Missing data.

the percentages formed by dividing the digits correct by the total digits for each skill a decision was made whether to continue testing with a single probe for that skill or to discontinue testing the skill. Only the first five pinpoints falling in this category of greater than 50% accuracy were tested further with single probes. It was decided by the experimenter that this would give sufficient data for the teachers to instruct on during the summer program. The additional sessions required for testing additional skills would have decreased valuable instructional time. Those pinpoints which the computer and teacher made different decisions about are included in Table 2. Further data were collected on these probes.

There was a total of 270 scores which were obtained by both the computer and teacher assessments with the proper information for comparison. Following the criteria for disagreement presented earlier, 24 (about 8.9%) of these were tested further. Raw scores and percentage scores are included in Appendix D. Table 4 summarizes the results. The computer was accurate in its prediction of learner performance in 54% of the cases in disagreement. That is, the category classification of the computer assessment for a skill was within one category of the classification arrived from averaging the follow-up data. The teachers, however, were accurate in about 37% of the cases in disagreement. (In the remaining cases both the teacher and computer were inaccurate in predicting learner performances.)

Table 4

Summary of Follow-Up Data
For Disputed Skills

Learner	Total Skills Disputed	Computer More Accurate	Teacher More Accurate	Dispute Undecided
1	2	0	2	0
2	3	1	1	1
3	3	3	0	0
4	5	3	2	0
6	3	2	1	0
7	7	3	1	3
9	1	0	1	0
Totals:	24	12	8	4

That is, both of the category classifications from the teacher and computer assessments were at least two categories off when compared with the follow-up data.

Comparison of Typing Digits with Writing Digits

When the tool skill speed of writing digits was compared with the tool skill speed of typing digits, resulting correlations were as high as .88 and as low as .48. Correlations describing the relationship between typing and writing digits are included in Table 5. Correlations involving the first administration of writing digits were not significant. Correlations of the second administration of writing digits and typing digits ranged from $r = .74$ to $r = .78$. Although these findings indicate the possibility of a relationship between writing and typing digits, further research is needed to establish such a relationship.

The purpose of the computerized precision assessment was to predict the rate and accuracy of writing answers. In order for the computerized assessment to be practical for use as a precision assessment, a definite relationship should be demonstrated between writing digits and typing digits. The strength of this relationship was not established in this study.

Two possible reasons accounting for the nonsignificant correlations are (1) the possibility that the duration of the training sessions were not of sufficient length to show

Table 5

Correlation Coefficients for Rates (Digits/Mins.) of Correct Responding of Writing and Typing Digits

Typing Digits on Computer Keyboard	Writing Digits on Tool Skill Probe: Trial 1	Writing Digits on Tool Skill Probe: Trial 2
Trial 1	$r=0.48$ $n=9$	$r=0.74$* $n=9$
Trial 2	$r=0.60$ $n=7$	$r=0.78$* $n=7$

Typing Digits (Correlation of Trials 1 with 2)	Writing Digits (Correlation of Trials 1 with 2)
$r=0.88$* $n=7$	$r=0.84$* $n=9$

*Correlation significant at the $\alpha=.05$ level.

the existing relationship, and (2) the possibility that the skills of writing and typing digits are unrelated, and, therefore, lack a relationship.

Until the relationship of typing and writing digits has been established, the use of the computer for precision assessment should be questioned.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

This study was conducted in order to investigate the feasibility of using the PLATO computer system for a precision assessment of elementary mathematics skills. A necessary element of any assessment is accuracy of assessment. The accuracy of computer administration of the SPARK instrument was determined by comparison with a teacher administration of the SPARK covering the same skills. The findings which were different between the computer and teacher assessments were followed up by the experimenter with four days of timed daily performance samples of the disputed skills. The computer assessment performed remarkably well when compared with the teacher assessment. The computer and teacher assessments agreed on the performance of approximately 91% of the skills tested. The computer assessments accurately predicted learner performance on 54% of the disputed cases. The teacher assessments accurately predicted 37% of the cases in disagreement. It should be noted that the reliability might have been better assured if the teacher and computer assessments had been repeated over several days. This could have been much better accommodated had the PLATO

system been on the same campus as the teacher assessments. This was not the case in the present study.

In order for an assessment to be useful and practical, it must be able to be administered within a reasonably short time. Again, when compared with the teacher assessment, the computer assessment seemed superior with respect to preparation and administration time. Due to the programing design, in many cases the computer assessment administered more problems than the teacher assessment. However, the computer assessment averaged 5.7 times faster than the teacher assessment for the same skills. This represents an immense reduction in the time typically spent on assessment. These findings, therefore, support other research studies which have shown the advantages of computer diagnosis over teacher diagnosis (Ferguson, 1971; Hus & Carlson, 1973; Jones & Sorlie, 1976). It is difficult to make a fair comparison between the time of the computer assessment and the time of the teacher assessment used in this study. A large portion of the teacher assessment was due to time taken to gather and organize materials. It could be argued that it takes many hours to program the computer for the computer assessment and that programing time should be included in the time comparison. The on-line programing for the assessment for this study took approximately 80 hours over a period of 4 months. This does not include time spent programing with paper and pencil or consulting time. Programing, however, is a one time effort, whereas the gathering and organizing of materials recurs with each teacher assessment or group of assessments.

The relationship between writing and typing digits needs to be established before rate data should be included in the computer assessment. The relationship between writing and typing digits was not established in this study; the correlations between them varied from .09 to .94, with an overall correlation of .50. One possible solution to increasing the correlations would be to increase the time for training the typing of digits. One could argue that an increase in training time would cause an increase in assessment time. However, those using the computer assessment would probably use the computer for other teaching activities. Just as the time spent learning to write digits was not included in the teacher assessment time, the time spent learning to type digits need not have been included in the assessment.

The computer assessment in this study required that the examiner remain with the student throughout the assessment to sign the student on to the computer, explain the computer usage, and to assist with reading the directions. There are several possibilities of avoiding or reducing this expenditure of teacher time. Among these are teaching the vocabulary included in the directions before the assessment, recording the assessment instructions, teaching a small number of students to assist students during the assessment, or a combination of these. The assessment could also be divided into several shorter assessments composed of the same format. The teacher

could assist the student during the first assessment, and the students could function on their own during the following assessment periods.

It is suggested that further study explore the utilization of microcomputers for assessing mathematics skills as the cost of the PLATO system is prohibitive in most cases. However, if the PLATO system were already available, this type of assessment could be used to better utilize the available software.

It is also suggested that the assessment be expanded to include more advanced mathematics skills such as regrouping, long multiplication, and long division, as those skills implemented in this study did remarkably well.

With the computer's capacity to dramatically reduce the assessment time with comparable accuracy, to assist with record keeping, and to possibly time mathematics assessments, it is clear that the computer could be utilized as a valuable assessment tool.

The development of an accurate computer assessment which can be utilized as a precision assessment needs to be explored further. Further research should establish a relationship between writing digits and typing digits.

This study compared computer assessment with teacher assessment using rate and accuracy criteria, and found that (1) teacher assessment and computer assessment were comparably accurate and (2) the computer accomplished the tasks required for assessment quicker. Based on this limited

research effort, until the relationship between writing digits and typing digits is established, computer administered precision assessment should be questioned.

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APPENDIX A

INSTRUCTIONS FOR THE PLATO ASSESSMENT

After the experimenter has signed the student on to the computer terminal and both the experimenter and the student are sitting in front of the terminal, she says:

"I would like to introduce you to PLATO. PLATO can be lots of fun. We'll start out learning some of the parts of the keyboard that you'll need to know. The numbers are on the top row."

The experimenter then points to the numbers and says:

"Notice the zero has a line through it."

The experimenter points to the zero and then says:

"Another important key is the NEXT key."

The experimenter points to the NEXT key and continues:

"You will need to press the NEXT key after each answer so that PLATO will know that you're ready. Whenever you don't know what to do, press NEXT. Would you like to begin reading the screen to me, or would you like me to read it to you?"

The experimenter begins the introduction lesson on PLATO. When the student has met the digit typing criteria of 95% accuracy, the assessment begins.

The experimenter then calls for the assessment program to be presented to the learner and says:

"Now that you have learned how to work with PLATO, PLATO is going to ask you to do some math problems. Some of them will be very easy for you, and some of them will not be easy for you. Do the best that you can on each one, but don't waste alot of time on any problem, because PLATO will be timing you. If you do not know the answer, type in the best answer that you can, and then press NEXT. Before you start each set of problems, PLATO will go over an example for you. Do you have any questions?"

The experimenter pauses for any questions and then says:

"Let's go over the first example together."

APPENDIX B

A COMPARISON OF THE COMPUTER AND TEACHER ASSESSMENTS

Since the computer and teacher assessments were both based upon the SPARK instrument, the procedures for administration are similar. One major difference is the time framework. The computer assessment was administered in one sitting in one day, whereas the administration of the teacher assessment consisted of more than one day. This time difference was primarily due to the scoring and recording mechanics programmed for the computer, which were done almost instantly. Therefore, the student was branched to the appropriate single probes immediately. The teacher assessment involved similar predetermined branching rules based on the student's performance on the mixed probes, but required a time to enable hand scoring and recording by the teacher. The following represents a summary of the procedures for computer and teacher assessments and sample outputs of the computer display.

Computer Assessment

Advanced Preparation

1. The experimenter programmed the computer and then modified the program after the pilot study.

Day 1

2. The experimenter signed on and gave the learner instructions.

3. The learner completed the interactive computer program designed to familiarize the learner with the keyboard.

4. The learner was administered the tool skill probe by the computer.

5. If the learner performed with 95% accuracy, the mixed probes were administered by the computer. If 95% accuracy was not yet attained, the learner was recycled back through the program for further practice.

6. The computer scored and recorded the mixed probes and selected the single probes based on performance. (The first five skills with 50% or greater accuracy for each strand.)

7. The computer administered the single probes.

8. The computer administered the tool skill probe for the second time.

Teacher Assessment

Advanced Preparations

1. Each teacher examiner participated in the training workshop, and gathered, duplicated, and organized the testing materials.

Day 1

2. The teacher examiner gave instructions and passed out the mixed probes.

3. The teacher examiner administered the tool skill probe.

4. The teacher administered the mixed probes.

5. The teacher scored the mixed probes and selected the single probes to administer based on the performance. (The first five skills with 50% or greater accuracy for each strand.)

Day 2

6. The teacher administered the tool skill probe and single probes.

7. The teacher scored and recorded the probes given.

Tables 6 through 9 represent a sample run of the computer assessment, from the introduction of the keyboard through the mixed and single probes. Often only part of the test was displayed at a time until the "next" key was depressed. Tables 10 through 13 are from a sample run of the computer's records of the student data for each strand. Tables 14 and 15 are samples of the single and mixed probes from the teacher assessment. These were administered as a paper and pencil test, or put in a plastic cover and marked with a water soluable pen such as a Vis-a-Vis pen. The teacher examiner made the choice between the two.

Table 6

Sample Display From Introductory Keyboard Exercise

Now PLATO is going to see how well you
have learned where the numbers are.

First, tell me your first name »

Table 6--continued

As the numbers appear, find the number
on the keyboard, and type it.

Be sure to press the NEXT key after each number
so that PLATO will know that you are finished.

press→ NEXT for more, diane

Table 6--continued

What do you do if you make a mistake?
You erase it! PLATO has a special key for
that. It says "ERASE" on it.
Type a number in right here and then erase it.
2 ok

Super! And you don't even have to wear out your
eraser!

Be sure to erase any mistakes BEFORE you press
NEXT, because after that it's too late.

Table 6--continued

Press the key with 1 on it to make the frog jump.

Be sure to press next after the number.

Table 6--continued

Good, diane, now press the 2 to make
two frogs jump.

Table 6--continued

HOW MANY FROGS DO YOU SEE?

>

Table 6--continued

Press NEXT if you think you know the number keys.

Press BACK if you want to try the numbers again.

Table 6--continued

Now that you know where the keys are, we will do a drill

to see how well you can type the numbers. Type the

numbers as quickly and correctly as you can.

Plato will keep repeating the drill until you get
most of them right (95%).

press→ NEXT for more, diane

Table 7

Sample Display From Toolskill Probe

TOOL SPEED PROBE

5	7	9	4	2
5	7	9	4	2

You scored 3Ø digits correct per minute

You scored Ø digits incorrect per minute.

End of drill, press NEXT please

Table 8

Sample Display Preceding
Administration of a Mixed Probe

HI THERE! My name is
Mr. Division and I'm
going to help you
with this lesson.

Let's work one together.

$$\begin{array}{r|l} & \text{3 ok} \\ \hline 3 & 9 \end{array}$$

Great! I can see you know how to do these
so we can go ahead and start the drill.
Press NEXT, please.

Table 9

Sample Display of a Mixed Probe

MIXED ADDITION PROBE

2	5	Ø	2	2
+ 8	+ 8	+ 7	+ 2	+ 1
1Ø	13	7	4	>

Table 10

Sample Display From Instructor's Access to Student Data

Division Index for Instructors
Student Data

a	Mixed division probe
b	Single probe for ONE's
c	Single probe for TWO's
d	Single probe for THREE's
e	Single probe for FOUR's
f	Single probe for FIVE's
g	Single probe for SIX's
h	Single probe for SEVEN's
i	Single probe for EIGHT's
j	Single probe for NINE's
k	Single probe for TENS's
l	Clear student data

Table 11

Sample Display for Mixed Probe Data

Data for student: gene d

	Correct/min	Incorrect/min.
Zeros	1Ø	Ø
Ones	6	2
Twos	2	1
Threes	8	4
Fours	2	7
Fives	3	2
Sixes	Ø	8
Sevens	2	8
Eights	Ø	8
Nines	Ø	3

Digits per minute correct: 1

Digits per minute incorrect: 3

press→NEXT for the index
BACK to select another student

Table 12

Sample Display Record for Single Probe Data

Data#1 for student: lenny d

	Correct/min	Incorrect/min.
Zeros	48	Ø

Digits missed

Zeros	Ø
Ones	Ø
Twos	Ø
Threes	Ø
Fours	Ø
Fives	Ø
Sixes	Ø
Sevens	Ø
Eights	Ø
Nines	Ø

press→ NEXT for more probe data for this student
BACK to select another student

Table 13

Sample Display for Tool Skill Data

Type the NUMBER of the student: >

		Tool Speed		
		Last	First	Tries
1	diane t	94/2	68/Ø	2
2	cal	Ø/Ø	Ø/Ø	Ø
3	patrick b	28/Ø	28/Ø	1
4	michael b	46/Ø	42/Ø	2
5	kimberly b	5Ø/Ø	44/1	2
6	bill b	12/1	18/Ø	2
7	gene d	3Ø/Ø	3Ø/Ø	1
8	lenny d	36/Ø	28/Ø	2
9	rick g	48/Ø	32/1	2
1Ø	brady g	48/Ø	48/Ø	1
11	kenneth g	38/Ø	36/Ø	2
12	denise d	42/Ø	36/Ø	2
13	john	Ø/Ø	Ø/Ø	Ø

press→ BACK to return to index

APPENDIX C

SEQUENTIAL PRECISION ASSESSMENT RESOURCE KIT

The SPARK arose out of a need in the area of special education. The authors of the SPARK are each certified in one or more areas of special education. Many of the academic problems learners have are due to "gaps" in a learning sequence. This is particularly true with exceptional learners. The SPARK breaks down various skills into more discrete steps, to help eliminate or remediate the gaps of learning. Although there is no "ideal" sequence of steps, the steps are available for use according to the individual needs of each learner. Because a high number of learning disabled individuals have problems in writing digits, the speed and accuracy becomes particularly important for them. If speed of performance is not stressed along with accuracy, many students do not attain the fluency of performance required by standardized tests.

The SPARK was field tested for three consecutive summers in the summer exceptional student education program at P. K. Yonge, the University of Florida's experimental school. The population upon which it was field tested was primarily learning disabled.

Table 14

Sample Display for a Mixed Probe from the Teacher Assessment

MIXED ADDITION PROBE STEPS 1.- 11

0 +7	1 +8	2 +6	3 +9	4 +3	5 +6	6 +5	7 +5	6 +8	9 +1	10 +3
6 +0	6 +1	2 +8	3 +6	1 +4	5 +0	6 +5	3 +7	8 +4	9 +3	5 +10
5 +0	1 +7	3 +2	5 +3	5 +4	1 +5	3 +6	7 +2	5 +8	3 +9	10 +7
0 +4	8 +1	2 +7	1 +3	4 +3	5 +4	1 +6	7 +0	2 +8	7 +9	2 +10
0 +6	1 +9	4 +2	3 +3	4 +7	5 +3	3 +6	7 +9	8 +1	9 +5	10 +8
0 +3	1 +6	2 +5	3 +9	4 +7	5 +5	6 +2	7 +9	8 +6	9 +4	6 +10

Table 15

Sample Display for a Single Probe from the Teacher Assessment

BASIC ADD FACTS - 8's

9 +8	8 +5	4 +8	8 +3	7 +8	8 +6	1 +8	8 +0
3 +8	6 +8	8 +2	1 +8	7 +8	8 +4	3 +8	2 +8
4 +8	3 +8	8 +4	9 +8	8 +6	7 +8	8 +8	8 +0
0 +8	1 +8	8 +4	3 +8	2 +8	8 +8	8 +2	9 +8
3 +8	7 +8	6 +8	8 +4	3 +8	8 +2	8 +1	4 +8
1 +8	7 +8	8 +0	4 +1	8 +3	7 +8	8 +8	2 +8
1 +8	8 +8	7 +8	8 +6	4 +8	8 +1	2 +8	3 +8

SPARK is an instrument for precision assessment. It is designed to be used by teachers in the classroom for assessment of basic skills in math, reading, and writing. The skills measured by SPARK are organized into curriculum strands. Each curriculum strand contains many related skills which are broken down into discrete skill steps. Although there is no "ideal" sequence of curriculum which would optimize learning for all students, the small steps help to avoid gaps in learning.

Each skill in SPARK can be assessed individually with a single probe, or the teacher may sample a number of skills simultaneously with a mixed probe. Probes are always timed for a minute or more. This allows the teacher to determine the learner's speed as well as accuracy for a given skill.

SPARK is a criterion-referenced instrument. The content validity for SPARK is high since the skills assessed and the probes used to assess them are identical. Test-retest reliability results are presented in Table 16. These figures were determined by administering a wide sample of probes from the SPARK on two consecutive days to children who had no previous exposure to SPARK. In practice, SPARK is even more reliable than the figures presented since the administration procedures require multiple presentation of probes beyond the second day.

Table 16

Test-Retest Reliability Scores for Probes from the SPARK

	Digits/Minute Scores	Percent Correct Scores
Mixed Probes for Mathematics	r =.80 n = 46	r =.73 n = 46
Tool Skill Probes	r =.98 n =106	r =.81 n =106
Single Probes for Mathematics	r =.96 n = 62	r =.66 n = 62

Note. Further information describing reliability of the SPARK and procedures used is contained in the Sequential Precision Assessment Resource Kit (Trifiletti, Rainey, & Trifiletti, 1977).

Precision Assessment

Precision assessment is a procedure for targeting deficient academic and social skills in a learner's repertoire. Precision assessment is used for both initial assessment and continuous monitoring of progress. Precision assessment involves measurement of the fluency and accuracy of a learner's performance under a particular instructional procedure. These performance data are used for decision making, as well as setting realistic goals and expectations.

Probes

The basic technique of precision assessment is the timed performance sample or probe. After giving directions, probe items are presented and the learner's performance is recorded over a short period of time, usually one minute. A probe of a learner's ability to write digits would consist of verbal directions to write digits zero through nine, and the learner's written response during one minute of observation. The difference between a conventional test and a probe is that the items on a probe are designed to represent a single skill which is a small step toward more complex skills. For example, one small step is multiplying fives. This step, along with other steps make up the skill of multiplying the numbers from zero to nine. Although the larger steps are divided into finer steps, the order of the steps should be tailored to the individual's needs.

The learner's performance is timed, allowing a measure of fluency. The measurement is repeated at short intervals of time, usually one day, allowing high reliability of measurement. The SPARK is essentially a battery of probes covering many academic skills.

Mixed and Single Probes

Since every academic skill in the learner's repertoire need not be assessed in depth, two types of probes are used, mixed and single probes. Mixed probes have many different academic skills. For instance, a mixed probe for addition might contain problems representing addition facts one through ten. A single probe contains items representing only one specific skill. For example, the single probe for addition facts 7's contains only simple addition problems with "7" as one of the addends in every item. Single probes give the fluency and accuracy values for specific skills. They form a baseline for continuous monitoring as the learner moves toward mastery of a skill.

Strands

For organizational purposes, skills are arranged in strands. A strand is a list of related probes arranged somewhat arbitrarily. The math area of SPARK is divided into strands for readiness, addition, subtraction, multiplication,

division, time, money, and fractions. The reading area of SPARK is divided into strands for readiness, phonics, structural analysis, contextual analysis, and reading text. Manuscript writing includes strands for readiness, vertical letters, slant letters, and circular letters. Cursive writing has strands for lower case and capital letters.

Mixed probes quickly assess the learner's skill within a strand. Mixed probes have items from many skills in a strand. Single probes are based on strands also. There is a single probe for every skill in a strand.

Tool Skills

There are certain skills which are considered prerequisite to more complex skills. Saying and writing digits is necessary to demonstrate many math skills. Saying and writing letters and saying letter sounds are prerequisite to many reading and language skills. Because these skills are so important, they are called "tool" skills and are assessed each day of the initial assessment. Tool skill rates are used to set goals for complex skills which build upon them.

Follow Along Sheets

There are three ways in which a learner can respond during a probe. The learner can "say," "write," or "do"

something. If the learner's response is a say or do movement, it is helpful for the teacher to have a copy of the probe for scoring. Such a probe is called a follow along sheet.

Administering Initial Precision Assessment

The initial precision assessment takes about 30 minutes per day and four or five consecutive days. During this period three types of probes are administered; tool skill probes, mixed probes, and single probes. To insure reliability, all probes are administered more than once. Tool skill probes are administered each day of assessment.

The following diagram shows the administration schedule for the various types of probes.

	Day 1	Day 2	Day 3	Day 4
Tool Skill Probes	X	X	X	X
Mixed Probes	X	X		
Single Probes			X	X

Selecting Probes to Administer

The tool skill probes which should be administered are saying digits, writing digits, saying letters, and writing letters. In many instances other tool skills are of interest. Probes in the readiness strands are often considered prerequisite to more complex skills.

For this reason readiness skills are often chosen as tool skill probes during initial assessment.

The selection of mixed probes depends upon the learner's previously demonstrated ability (if known), and the teacher's purposes for assessment. If the teacher is a reading specialist responsible only for reading achievement, mixed probes are selected to cover a wide range of reading skills. If the teacher is responsible for all academic areas, mixed probes from several strands should be selected to provide a broad assessment base.

Prior knowledge of the learner's abilities also influence selection of mixed probes. For instance, if the teacher is sure the learner knows the basic multiplication facts, a mixed probe with more advanced multiplication items should be selected.

The choice of single probes depends upon deficient skills which show up during administration of the mixed probes. After scoring the mixed probes, deficient skills are identified. These deficient skills are assessed in depth with single probes.

Administering Mixed Probes

The purpose of the mixed probe is to quickly identify deficient skills and guide the selection of single probes. Problems from several related skills appear on a mixed probe. The teacher should allow enough time for the learner to

attempt a few items from each skill. The learner is instructed to work as quickly and accurately as possible, from left to right, and to attempt each item. The teacher demonstrates a few items and gives any directions necessary to insure the learner's best performance. Before starting, the learner should have an opportunity to ask questions. During the probe, the teacher does whatever is necessary to maintain on-task behavior, but refrains from cues or prompts which would inflate the learner's performance.

Scoring Mixed Probes

Mixed probes need only be scored in terms of the skills incorrectly performed. On most of the mixed probes speed and accuracy measures are not really useful since mixed probes contain several different skills, some of which may take considerably longer than others. The skills on mixed probes are arranged vertically in columns. For example, on the Mixed Addition Probe Steps 1-11, the skill of addition facts 0's is in the first column, addition facts 1's is in the second column, addition facts 2's is in the third column, etc. The skills in the columns follow the same arrangement as the skills on the strands. Skill number 11 in the addition strand is the eleventh column of the Mixed Addition Probe Steps 1-11.

After the learner has completed a few rows of items, a pattern of errors will become clear. The teacher uses

this error pattern to select single probes for in-depth assessment.

Administering Single Probes

Single probes are usually administered for one minute. The purpose of the single probes is to determine fluency (speed) and accuracy on skills which have potential as instructional targets. The teacher needs a stopwatch or timepiece with a seconds display for timing. For "say" or "do" movements, a follow along sheet is required. Directions to the learner are similar to directions for mixed probes; work from left to right, attempt each item, work as quickly and accurately as possible. The teacher demonstrates a few items and allows questions before administering the probe. Tool skill probes are administered in the same manner as single probes.

Scoring Single Probes

Single probes are scored in terms of frequency of correct movements, and frequency of error movements. Frequency of correct movements (FC) is simply the number of correct movements divided by the time in minutes. For example, a learner who writes 46 digits correctly in 2 minutes with 12 errors has a frequency correct of 23 and an error rate of 6 movements per minute.

A few scoring conventions have developed which deserve attention. In math skills where digits are written, all digits including those in the answer are counted. This is especially important in advanced multiplication and division skills where several digits are written besides the digits in the answer per se. In spelling skills, each letter in correct position is counted as a correct movement, and each letter in incorrect position or omitted is counted as an error movement. In writing, the teacher's judgment determines correct and error movements. In reading, error movements consist of mispronounciations, omissions, repetitions, and substitutions.

Selecting Instructional Targets

At the conclusion of four or five days of initial precision assessment with SPARK, the following should be accomplished:

1. Deficient academic skills identified through mixed probes.

2. Fluency and accuracy of possible instructional targets determined with single probes.

3. Fluency and accuracy of tool skills determined with tool skill probes.

The next step is to select instructional targets from the mixed and single probes. Selecting instructional

targets involves weighing many factors including the age of the learner, parent and teacher expectations, time available for instruction, materials and resources present, etc. In situations where tool skills are slow or inaccurate, they can be targeted for instruction.

In general, instructional targets should be the highest skills on a strand for which the learner demonstrates some performance, but inadequate performance. In situations where there appear to be gaps in learning due to inadequate instruction, yet the learner has progressed to higher levels despite the gaps, such skills may be selected as instructional targets to be monitored on a weekly basis. Daily monitoring is necessary for skills which are substantially interfering with the learner's progress.

Continuous Monitoring with SPARK

Following initial precision assessment, instruction begins on the deficient skills that have been targeted. The data from the single probes are charted and displayed to form a brief baseline of initial performance. During the instructional period, that same single probe is administered daily, or as frequently as is feasible. Observation of the daily performance with this single probe facilitates instructional decisions to optimize the learner's growth toward mastery of the skill. A skill

is considered mastered when fluency and accuracy proficiency is demonstrated over three consecutive daily probes.

Instructional decisions which can be made to optimize learning are too numerous to mention here, but generally include alterations in directions, instructional materials, and contingnecies.

APPENDIX D

COMPUTER AND TEACHER ASSESSMENT DATA

Mixed Probes for Learner 1

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	12/12	100%	3/3	100%
+1	12/12	100%	2/3	67%
+2	6/6	100%	4/4	100%
+3	11/11	100%	4/4	100%
+4	2/3	67%	3/3	100%
+5	11/11	100%	4/4	100%
+6	5/5	100%	5/5	100%
+7	9/9	100%	5/5	100%
+8	12/14	86%	6/6	100%
+9	6/8	75%	6/6	100%
Subtraction				
-0	6/7	86%	5/5	100%
-1	8/8	100%	3/3	100%
-2	8/8	100%	4/4	100%
-3	6/7	86%	5/5	100%
-4	8/8	100%	3/3	100%
-5	6/7	86%	5/5	100%
-6	8/8	100%	2/4	50%
-7	6/7	86%	3/3	100%
-8	6/7	86%	4/4	100%
-9	8/8	100%	2/3	67%
Multiplication				
x0	6/7	86%	3/3	100%
x1	14/14	100%	3/3	100%
x2	3/4	75%	3/3	100%
x3	8/8	100%	3/3	100%
x4	5/5	100%	3/3	100%
x5	17/17	100%	3/3	100%
x6	8/8	100%	3/3	100%
x7	7/9	78%	3/3	100%
x8	13/16	81%	3/3	100%
x9	4/4	100%	3/3	100%
Division				
1	8/8	100%	3/3	100%
2	6/6	100%	3/3	100%
3	6/7	86%	3/3	100%
4	5/6	83%	3/3	100%
5	10/10	100%	3/3	100%
6	8/8	100%	3/3	100%
7	6/8	75%	3/3	100%
8	6/6	100%	3/3	100%
9	6/7	86%	2/3	67%

Mixed Probe for Learner 2

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	10/10	100%	3/3	100%
+1	4/4	100%	3/3	100%
+2	12/12	100%	4/4	100%
+3	4/5	80%	4/4	100%
+4	11/11	100%	3/3	100%
+5	13/13	100%	2/4	50%
+6	10/10	100%	3/5	60%
+7	7/8	88%	4/5	80%
+8	8/10	80%	6/6	100%
+9	3/4	75%	6/6	100%
Subtraction				
-0	8/8	100%	0/3	0%
-1	0/4	0%	*	*
-2	0/4	0%	*	*
-3	0/6	0%	*	*
-4	2/7	29%	*	*
-5	0/7	0%	*	*
-6	2/8	25%	*	*
-7	0/7	0%	*	*
-8	2/8	25%	*	*
-9	2/7	29%	*	*
Multiplication				
x0	0/5	0%	0/6	0%
x1	4/8	50%	3/3	100%
x2	6/6	100%	1/5	20%
x3	0/5	0%	0/6	0%
x4	0/8	0%	1/4	25%
x5	5/9	56%	0/6	0%
x6	0/6	0%	1/5	20%
x7	0/10	0%	2/6	33%
x8	2/7	29%	2/6	33%
x9	0/4	0%	0/6	0%

*Insufficient data

Mixed Probes for Learner 3

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	6/6	100%	3/3	100%
+1	4/5	80%	1/3	33%
+2	6/7	86%	1/3	33%
+3	6/10	60%	1/3	33%
+4	3/7	43%	1/3	33%
+5	5/7	71%	1/3	33%
+6	4/7	57%	1/3	33%
+7	0/3	0%	1/3	33%
+8	10/14	71%	1/3	33%
+9	11/13	85%	2/3	67%
Subtraction				
-0	8/8	100%	3/3	100%
-1	8/8	100%	3/3	100%
-2	8/8	100%	3/3	100%
-3	8/8	100%	3/3	100%
-4	6/7	86%	2/3	67%
-5	8/8	100%	3/3	100%
-6	8/8	100%	3/3	100%
-7	6/7	86%	1/3	33%
-8	8/8	100%	1/3	33%
-9	6/7	86%	1/3	33%

Mixed Probes for Learner 4

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	4/4	100%	0/3	0%
+1	4/4	100%	3/3	100%
+2	9/9	100%	2/3	67%
+3	6/6	100%	2/3	67%
+4	10/11	91%	3/3	100%
+5	17/17	100%	3/3	100%
+6	15/15	100%	3/3	100%
+7	10/10	100%	3/3	100%
+8	8/8	100%	3/3	100%
+9	10/10	100%	3/3	100%
Subtraction				
-0	6/7	86%	1/3	33%
-1	6/7	86%	2/3	67%
-2	8/8	100%	3/3	100%
-3	4/6	75%	3/3	100%
-4	8/8	100%	3/3	100%
-5	8/8	100%	3/3	100%
-6	8/8	100%	2/3	67%
-7	8/8	100%	1/3	33%
-8	6/7	86%	2/3	67%
-9	8/8	100%	3/3	100%
Multiplication				
x0	4/4	100%	3/3	100%
x1	6/6	100%	0/3	0%
x2	7/7	100%	2/3	67%
x3	11/11	100%	0/3	0%
x4	6/13	46%	0/3	0%
x5	13/16	81%	2/3	67%
x6	8/9	89%	0/3	0%
x7	0/4	0%	0/3	0%
x8	5/12	42%	0/3	0%
x9	12/15	80%	0/3	0%

Mixed Probes for Learner 5

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	0/6	0%	0/3	0%
+1	0/9	0%	2/4	50%
+2	0/13	0%	1/4	25%
+3	0/8	0%	1/5	20%
+4	0/6	0%	1/3	33%
+5	0/10	0%	0/4	0%
+6	0/11	0%	0/5	0%
+7	0/4	0%	0/5	0%
+8	0/17	0%	1/5	20%
+9	0/6	0%	4/6	67%

Mixed Probes for Learner 6

Probe	Computer Assessment: Correct/Total Digits	Computer Assessment: Percent Correct	Teacher Assessment: Correct/Total Digits	Teacher Assessment: Percent Correct
Addition				
+0	4/4	100%	3/3	100%
+1	9/9	100%	3/3	100%
+2	9/9	100%	4/4	100%
+3	9/9	100%	4/4	100%
+4	8/8	100%	3/3	100%
+5	17/17	100%	4/4	100%
+6	10/10	100%	5/5	100%
+7	3/5	60%	5/5	100%
+8	9/10	90%	6/6	100%
+9	16/16	100%	6/6	100%
Subtraction				
-0	8/8	100%	5/5	100%
-1	8/8	100%	3/3	100%
-2	8/8	100%	4/4	100%
-3	8/8	100%	2/3	100%
-4	8/8	100%	2/5	40%
-5	8/8	100%	2/3	67%
-6	8/8	100%	2/4	50%
-7	8/8	100%	2/2	100%
-8	2/5	40%	2/4	50%
-9	6/7	86%	*	*
Multiplication				
x0	10/10	100%	3/3	100%
x1	6/8	75%	3/3	100%
x2	2/3	67%	5/5	100%
x3	8/12	75%	1/2	50%
x4	2/9	22%	4/5	80%
x5	3/5	60%	4/4	100%
x6	0/7	0%	1/3	33%
x7	2/16	13%	0/3	0%
x8	0/8	0%	2/6	33%
x9	0/3	0%	0/2	0%

*Insufficient Data

Mixed Probes for Learner 7

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	10/10	100%	3/3	100%
+1	8/8	100%	3/3	100%
+2	6/8	75%	4/4	100%
+3	6/6	100%	2/4	50%
+4	2/6	33%	3/3	100%
+5	9/11	82%	4/4	100%
+6	4/6	67%	4/4	100%
+7	5/11	45%	4/4	100%
+8	0/2	0%	3/4	75%
+9	3/9	33%	4/4	100%
Subtraction				
-0	2/5	40%	3/5	60%
-1	8/8	100%	3/3	100%
-2	6/7	86%	3/4	75%
-3	8/8	100%	2/5	40%
-4	2/5	40%	1/3	33%
-5	6/7	86%	1/5	20%
-6	6/7	86%	1/3	33%
-7	2/5	40%	2/3	67%
-8	6/7	86%	0/4	0%
-9	6/7	86%	1/3	33%

Mixed Probes for Learner 8

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	4/4	100%	3/3	100%
+1	6/6	100%	3/3	100%
+2	11/11	100%	4/4	100%
+3	7/9	78%	4/4	100%
+4	12/12	100%	3/3	100%
+5	5/5	100%	4/4	100%
+6	8/9	89%	5/5	100%
+7	10/11	91%	5/5	100%
+8	14/14	100%	4/5	80%
+9	15/15	100%	6/6	100%
Subtraction				
-0	8/8	100%	5/5	100%
-1	8/8	100%	3/3	100%
-2	8/8	100%	3/5	60%
-3	8/8	100%	5/5	100%
-4	8/8	100%	2/4	50%
-5	6/7	86%	5/6	40%
-6	8/8	100%	4/4	100%
-7	6/7	86%	1/5	20%
-8	6/7	86%	2/6	33%
-9	8/8	100%	0/5	0%

Mixed Probes for Learner 9

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
Addition				
+0	8/8	100%	3/3	100%
+1	7/8	88%	0/3	0%
+2	10/11	91%	1/3	33%
+3	11/12	92%	2/4	50%
+4	4/4	100%	1/3	33%
+5	2/3	67%	3/4	75%
+6	7/11	64%	2/4	50%
+7	2/7	29%	2/5	40%
+8	6/10	60%	2/5	40%
+9	0/4	0%	2/4	50%
Subtraction				
-0	8/8	100%	4/4	100%
-1	4/6	67%	1/3	33%
-2	0/5	0%	2/6	33%
-3	0/4	0%	1/5	20%
-4	0/5	0%	0/5	0%
-5	2/7	29%	3/6	50%
-6	2/5	40%	0/6	0%
-7	2/5	40%	0/6	0%
-8	0/5	0%	1/5	20%
-9	2/5	40%	0/6	0%

Single Probe Scores for Learner 1

Probe	Computer Assessment: Correct/Total Digits	Computer Assessment: Percent Correct	Teacher Assessment: Correct/Total Digits	Teacher Assessment: Percent Correct
+0	48/48	100%	49/49	100%
+1	26/27	96%	29/29	100%
+2	24/24	100%	29/29	100%
+3	22/23	96%	35/35	100%
+4	20/22	91%	33/33	100%
-0	54/54	100%	60/60	100%
-1	40/41	98%	44/44	100%
-2	36/36	100%	37/37	100%
-3	22/25	88%	26/26	100%
-4	22/23	96%	17/17	100%
x0	102/102	100%	51/51	100%
x1	40/41	98%	22/22	100%
x2	25/25	100%	18/18	100%
x3	19/19	100%	16/16	100%
x4	9/13	69%	30/30	100%
÷1	43/43	100%	38/38	100%
÷2	12/14	86%	19/19	100%
÷3	20/21	96%	20/20	100%
÷4			20/20	100%
÷5	14/22	64%	23/23	100%

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 2

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	34/34	100%	28/28	100%
+1	27/27	100%	20/20	100%
+2	14/15	93%	12/12	100%
+3	16/16	100%	11/11	100%
+4	22/22	100%	15/15	100%
-0	31/31	100%	--	--
x2	8/14	57%	--	--
x1	--	--	13/13	100%

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 3

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	32/34	94%	42/42	100%
+1	14/15	93%	23/23	100%
+2	11/15	73%	14/14	100%
+3	19/25	76%	13/13	100%
+4	--	--	9/10	90%
+5	12/15	80%	--	--
-0	38/38	100%	36/36	100%
-1	18/18	100%	12/12	100%
-2	12/12	100%	10/10	100%
-3	10/12	83%	4/4	100%
-4	16/17	94%	11/13	85%

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 4

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	24/25	96%	--	--
+1	27/28	96%	*	*
+2	18/19	95%	4/4	100%
+3	16/18	89%	*	*
+4	16/17	94%	*	*
-0	11/11	100%	56/56	100%
-1	20/20	100%	17/17	100%
-2	26/26	100%	6/7	86%
-3	10/13	77%	*	*
-4	6/7	86%	*	*
x0	48/48	100%	--	--
x1	28/28	100%	27/30	90%
x2	19/19	100%	10/10	100%
x3	7/14	50%	16/17	94%
x4	--	--	10/10	100%
x5	36/36	100%	--	--

*Missing Data

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 6

Probe	Computer Assessment Correct/Total Digits	Computer Assessment Percent Correct	Teacher Assessment Correct/Total Digits	Teacher Assessment Percent Correct
+0	34/34	100%	60/60	100%
+1	27/28	96%	32/32	100%
+2	22/22	100%	32/32	100%
+3	26/26	100%	28/28	100%
+4	25/26	96%	52/52	100%
-0	29/29	100%	60/60	100%
-1	22/22	100%	32/32	100%
-2	16/16	100%	44/44	100%
-3	14/14	100%	17/18	94%
-4	22/22	100%	40/40	100%
x0	2/14	14%	0/56	0%
x1	18/18	100%	78/78	100%
x2	2/3	67%	18/18	100%
x3	2/12	17%	36/36	100%
x4	--	--	4/20	20%
x5	15/15	100%	32/32	100%

Note. Single probes were administered for one minute

Single Probe Scores for Learner 7

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	34/34	100%	52/52	100%
+1	6/21	29%	64/64	100%
+2	23/25	92%	32/44	73%
+3	17/22	77%	27/29	93%
+5	24/32	75%	*	*
-1	10/22	45%	0/64	0%
-2	14/21	67%	24/40	60%
-3	18/23	78%	15/16	94%
-4	--	--	20/29	69%
-5	22/30	73%	22/22	100%
-6	26/32	81%	19/28	68%

*Missing Data

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 8

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	38/38	100%	*	*
+1	29/29	100%	*	*
+2	26/26	100%	*	*
+3	21/22	95%	*	*
+4	24/24	100%	*	*
-0	42/42	100%	*	*
-1	36/37	97%	*	*
-2	18/19	95%	*	*
-3	30/30	100%	*	*
-4	26/26	100%	*	*

*Missing Data

Note. Single probes were administered for one minute.

Single Probe Scores for Learner 9

	Computer Assessment		Teacher Assessment	
Probe	Correct/Total Digits	Percent Correct	Correct/Total Digits	Percent Correct
+0	20/21	95%	52/52	100%
+1	15/16	94%	4/34	12%
+2	6/16	38%	8/25	32%
+3	5/14	36%	5/19	26%
+4	4/15	27%	2/15	13%
-0	20/22	91%	34/34	100%
-1	2/16	13%	5/9	55%

Note. Single probes were administered for one minute.

Data for Tool Skill Probes

	Computer Assessment		Teacher Assessment	
Learner	Tool Skill	Tool Skill	Tool Skill	Tool Skill
1	42/42	46/46	60/60	88/88
2	36/36	38/38	10/11	44/44
3	32/33	48/48	30/30	53/53
4	28/28	36/36	50/50	60/60
5	18/18	12/13	6/11	6/17
6	30/30	*	49/49	50/50
7	36/36	42/42	37/37	59/60
8	44/45	50/50	37/37	50/50
9	28/28	*	23/23	30/30

*Missing Data

Note. Tool skills were administered twice by the computer and twice by the teacher. Scores are reported in correct/total digits per minute.

BIOGRAPHICAL SKETCH

Diane Trifiletti was born in Norwich, Connecticut, on May 20, 1953. After attending elementary schools in both Onset and Chatham, Massachusetts, she completed her public school education in Dunedin, Florida. She was awarded her Associate of Arts degree from St. Petersburg Junior College in 1972. Upon receiving her Bachelor of Arts degree in psychology from the University of North Florida in 1974, she accepted a graduate assistantship with the Department of Special Education. She received her Master of Education in special education, certified in both emotional handicaps and learning disabilities in 1975. During that time she was co-director of Riverside Adult Group Living Home, a community-based educational program for mentally retarded young men.

Ms. Trifiletti taught three years in the Alachua County School System and one year at a private school for learning disabled children. Her teaching positions included elementary and junior high school age resource and self-contained units for learning disabled, emotionally handicapped, and retarded children. In December, 1979, Ms. Trifiletti will complete the requirements for the Doctor of Philosophy in curriculum and instruction in postsecondary education.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William H. Drummond, Chairman
Professor of Instructional Leadership and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William D. Hedges
Professor of Instructional Leadership and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Elroy J. Bolduc
Associate Professor of Subject Specialization Teacher Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Arthur D. King
Associate Professor of Instructional Leadership and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert F. Algozzine
Assistant Professor of
Special Education

This dissertation was submitted to the Graduate Faculty of the Division of Curriculum and Instruction in the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1979

Dean, Graduate School